

USGS Data Collection Activities to Support Regional Sediment Management

Jonathan A. Warrick

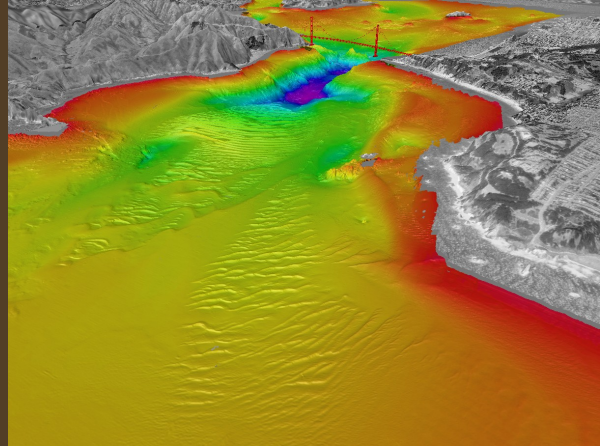
USGS Coastal and Marine Geology
Santa Cruz, CA

86th CERB Meeting
3-4 June 2009
San Diego, CA

Coastal turbidity following the

15 Dec 2008 discharge event
from the Tijuana River





Partners and Collaborators

- **Government Agencies:**

- U.S. Army Corps of Engineers (San Francisco District)
- California Coastal Conservancy
- California Ocean Protection Council (OPC)
- California Department of Boating and Waterways (DBW)
- California Sediment Management Workgroup (CSMW)
- California Coastal Commission
- California State Parks
- Beach Erosion Authority for Clean Oceans and Nourishment (BEACON)
- EPA
- NOAA (incl. National Weather Service)
- USCG
- NSF
- CALFED
- San Francisco Bay Conservation and Development Commission (BCDC)
- California State Lands Commission
- California Department of Fish and Game
- Tijuana Estuary National Research Reserve
- San Francisco Estuary Institute
- City of San Francisco

- **Private Sector and Non-Profits:**

- Phillip Williams and Associates
- Moffatt & Nichol Engineers
- Southwest Wetlands Interpretive Association (SWIA)
- Nautilus Environmental

- **Department of Interior**

- USGS Water Resources Division
- USGS Mendenhall Program
- USGS CMG Woods Hole and St. Pete
- National Park Service (Golden Gate NRA)

- **Academic Partners/Collaborators**

- California State University, Monterey Bay
- San Francisco State University
- University of Delaware
- Oregon State University
- University of California, Santa Cruz
- University of California, Berkeley
- University of California, Davis
- University of California, San Diego
- Stanford University
- Moss Landing Marine Lab
- Delft Hydraulics (a.k.a. Deltares)
- University of Queensland

USGS Data Collection

USGS Mission: The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

USGS Vision: USGS has become a world leader in the natural sciences thanks to our scientific excellence and responsiveness to society's needs

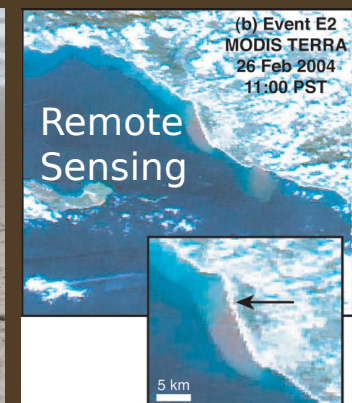
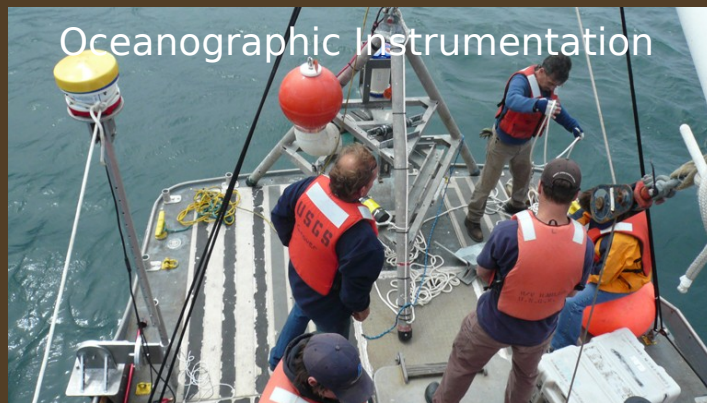
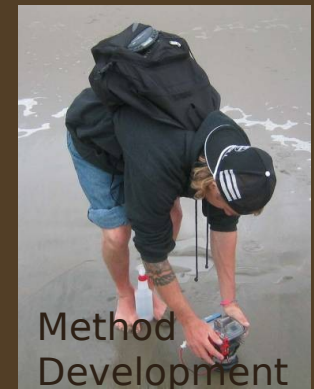
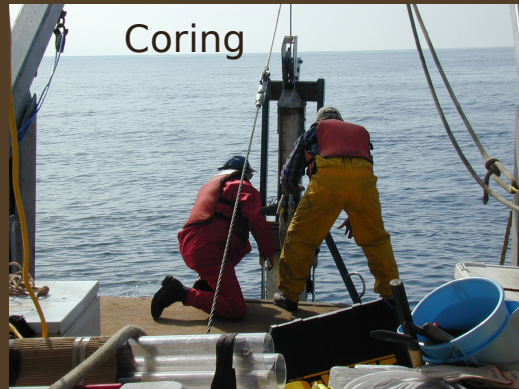
**Scientific
Method**

**Scientific
Questions
Data Collection
Analyses
Synthesis
Communication**





Data Collection Tools

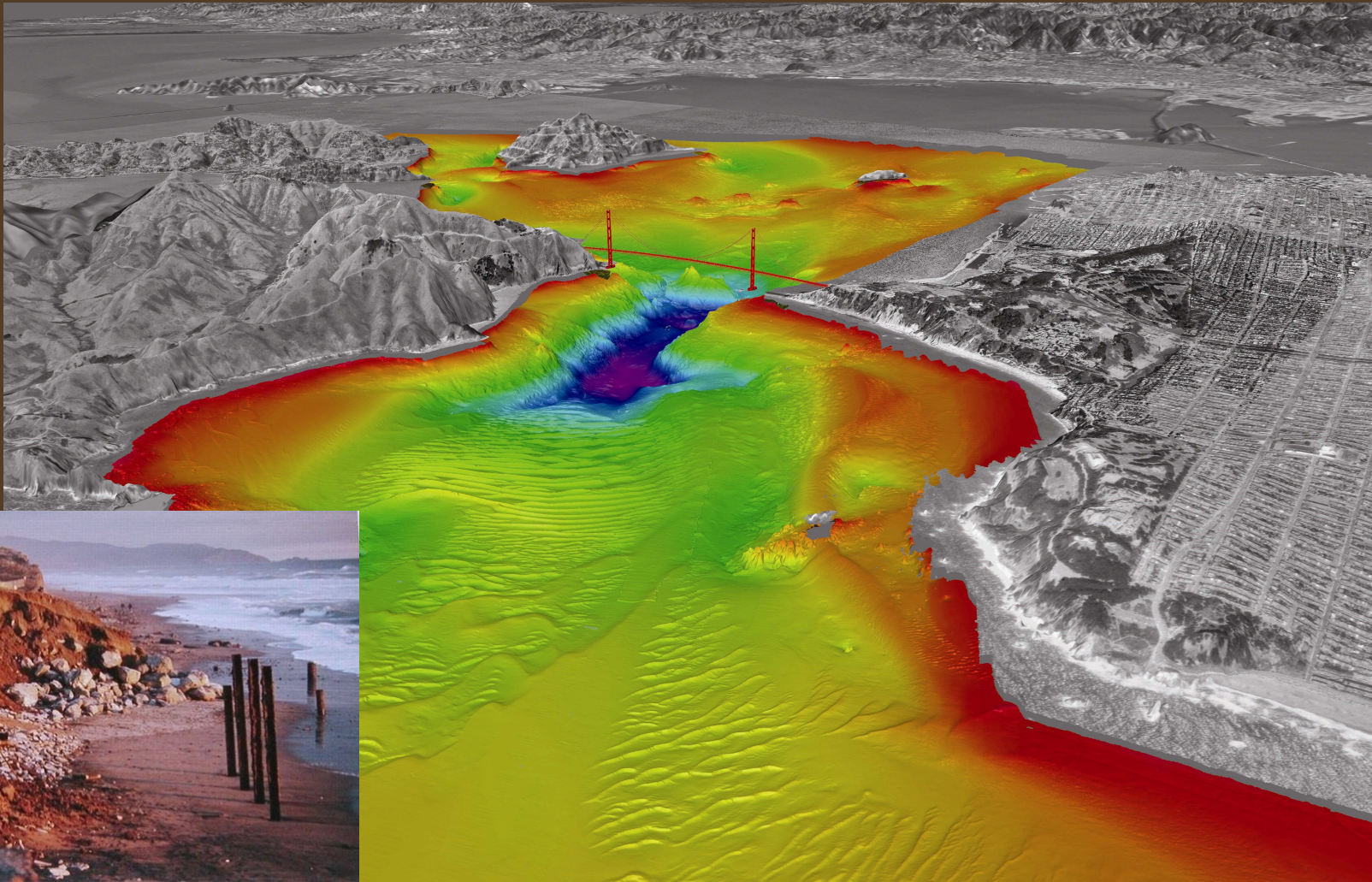


And many others... Geochemistry, Geophysics, Sediment Lab, Numerical Modeling...

Project Example 1 -

San Francisco Bay Coastal System

PI: Patrick Barnard, Ph.D.





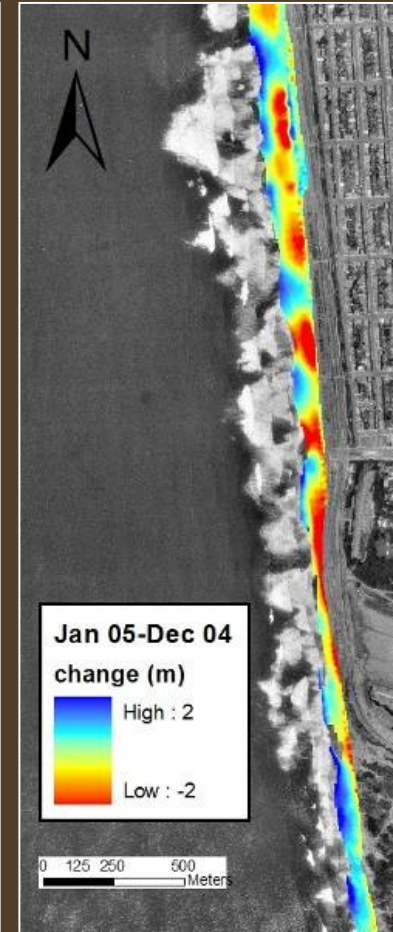
Beach Data Collection and Analysis

N Shoreline Change S

— June 2008- June 1
— Aug. 2008- Oct. 1
— Oct. 2004- Oct. 1



RTK DGPS Topography

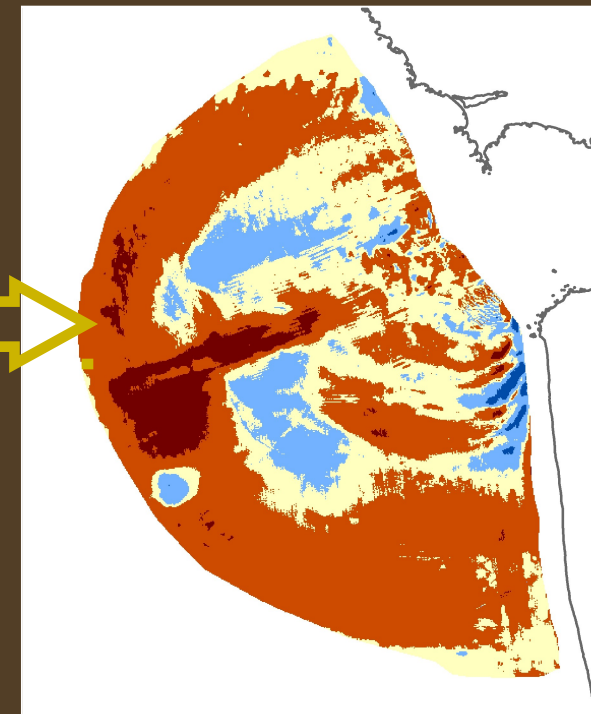
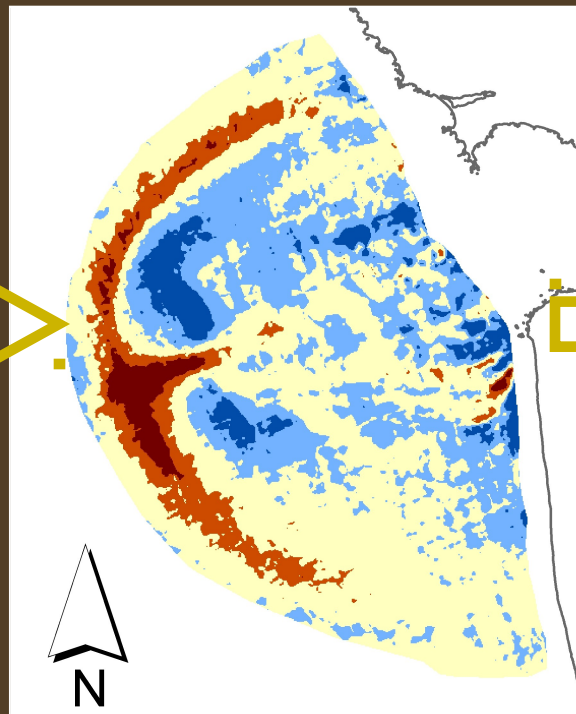
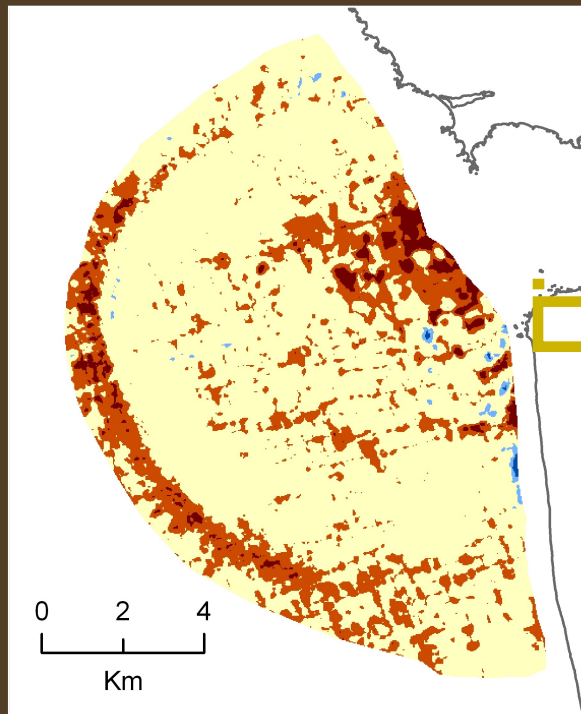


Bathymetric Change of SF Bay Ebb Bar

1873 to 1900

1900 to 1956

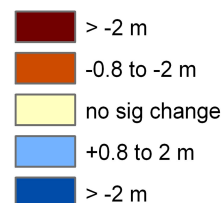
1956 to 2005



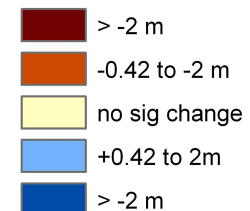
Depth Change



Depth Change



Depth Change



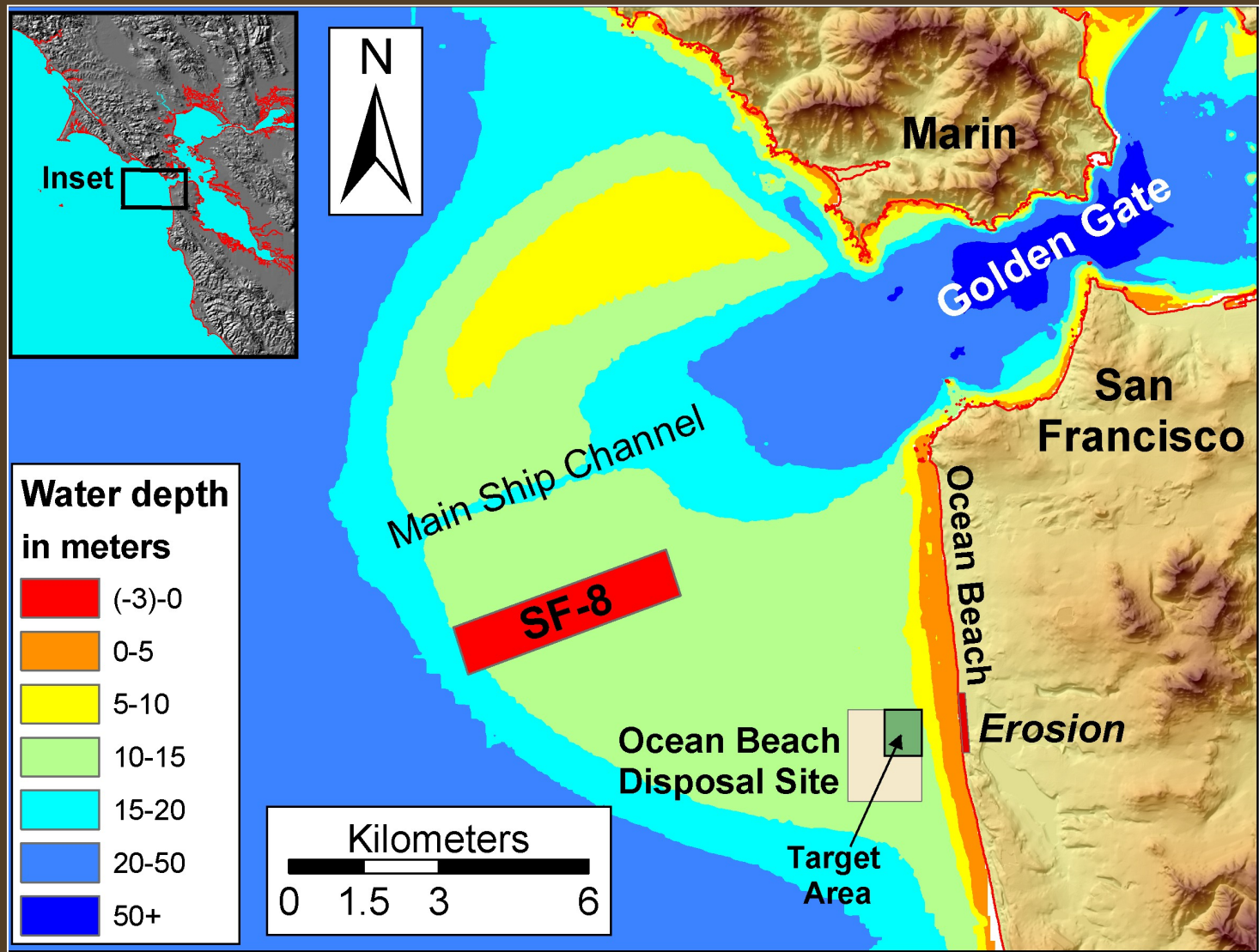
Performance of Nearshore Dredge Disposal, Ocean Beach, San Francisco, California: 2005- present



Photo courtesy
of Peter Mull

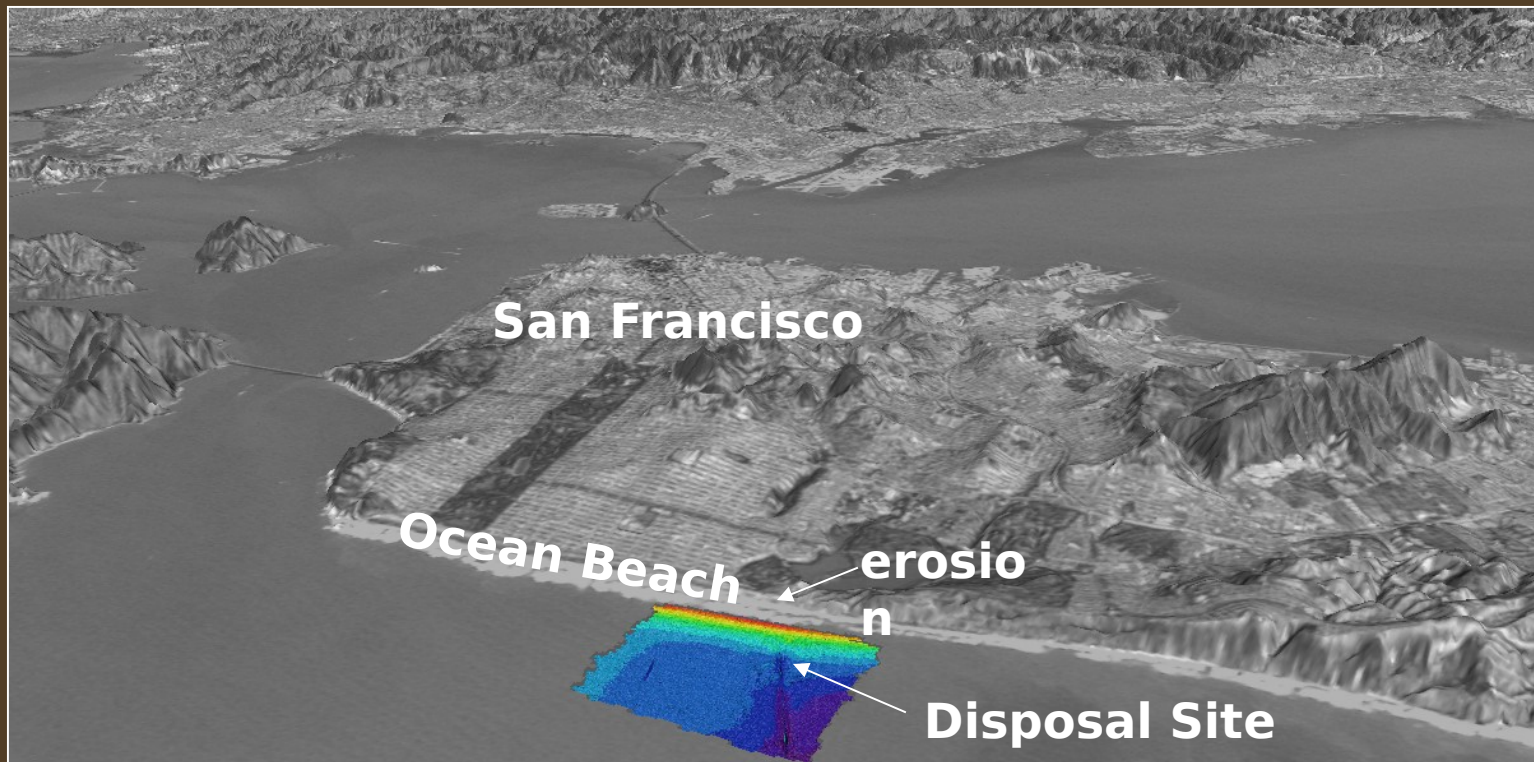


Nearshore Dredge Disposal





Monitoring Area



Summary of Disposal and Monitoring: 2005 to 2009

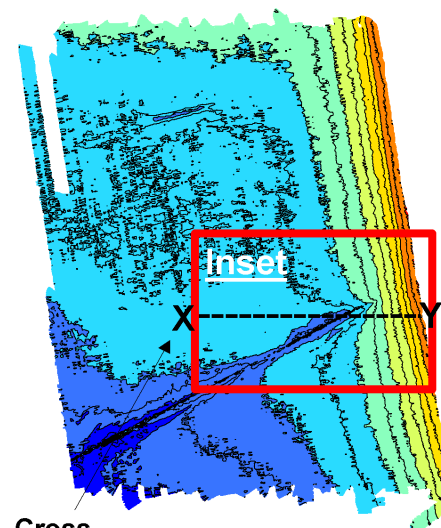
-3 annual nourishments of $\sim 225,000 \text{ m}^3$ each

-12 multibeam surveys, 36 topo surveys, 9 single-beam bathy surveys, 3 grain size surveys, 3 physical process experiments



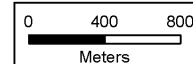
Nearshore Dredge Disposal

Survey 1, May 2005

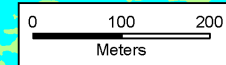
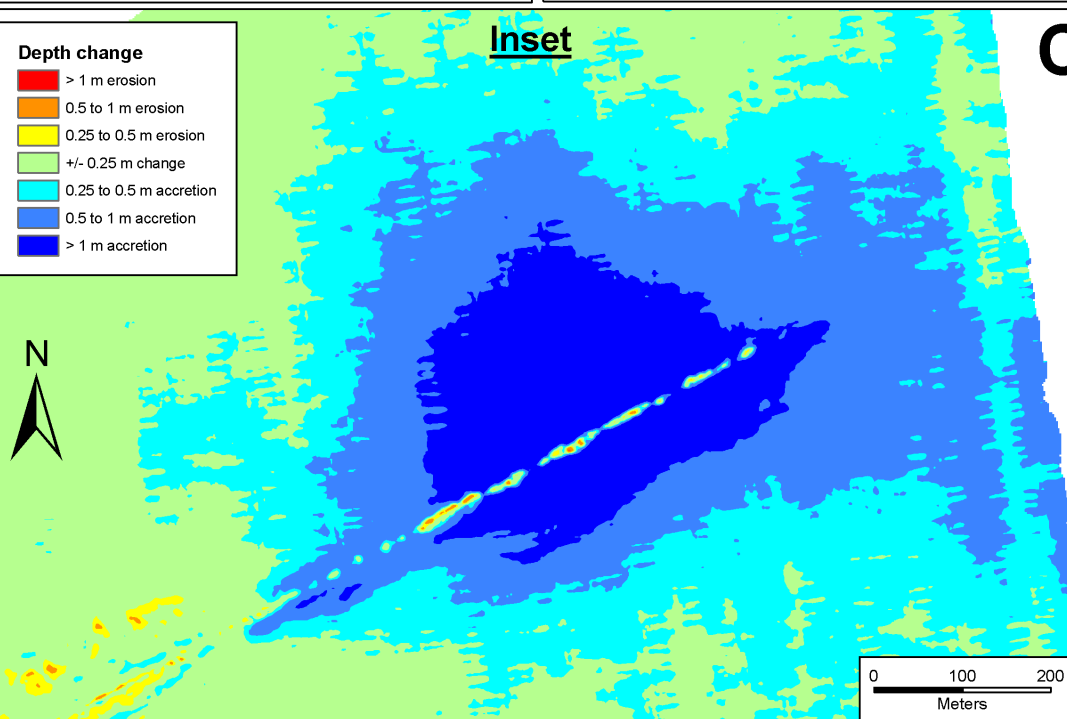
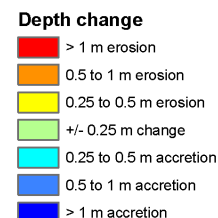
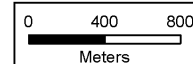
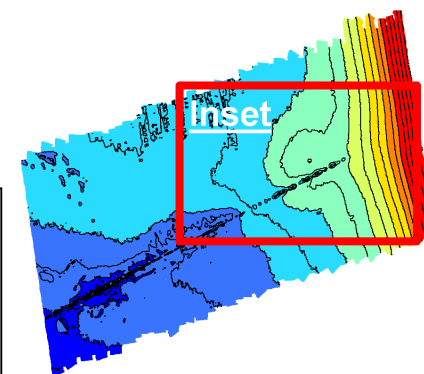


Cross
Section

Depth,
in meters

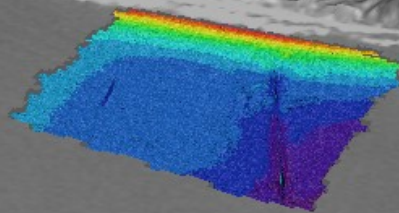


Survey 12, December 2007



Nearshore Nourishment Summary

Benefits



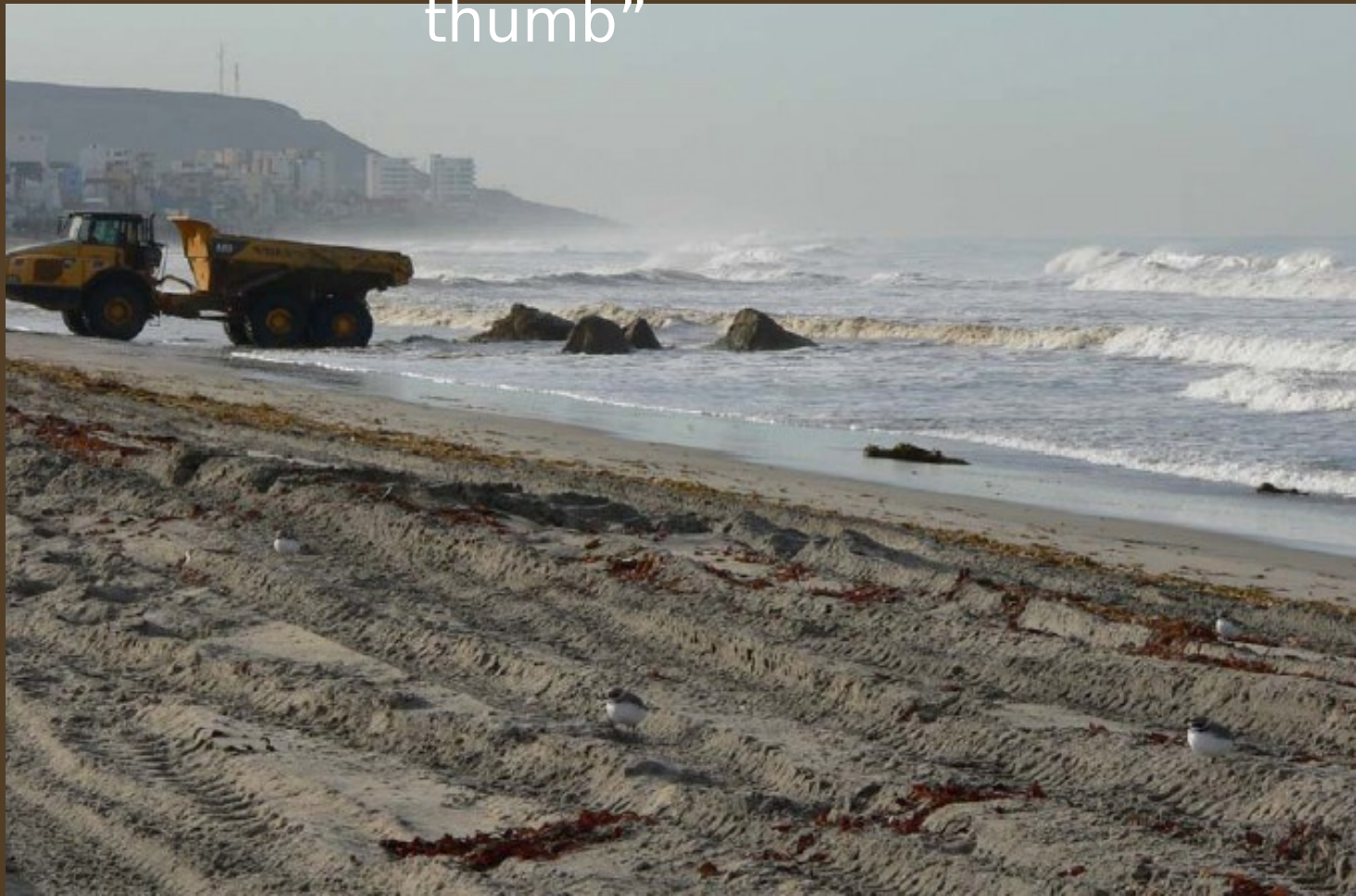
- Wave dissipation during winter storms
- Mound migration toward shore at rate of ~ 100 m/year during winter 06-07
- Outfall pipe protection
- Relieves stress on offshore disposal site

Project Example 2 -

Fate and Transport of Fine Sediment

PI: Jonathan Warrick, Ph.D.

80-20 “rule of thumb”



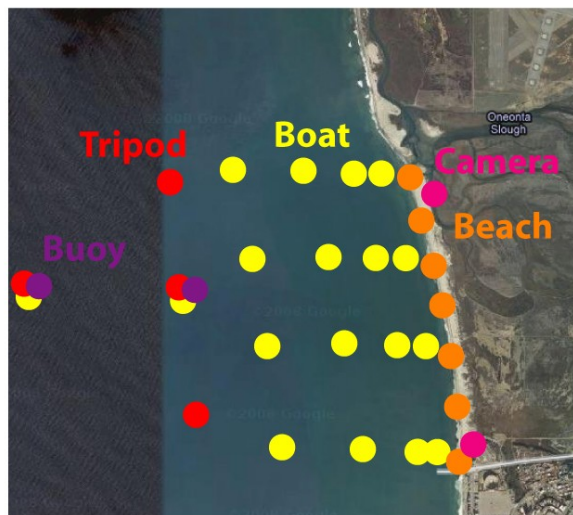
3

Placements:

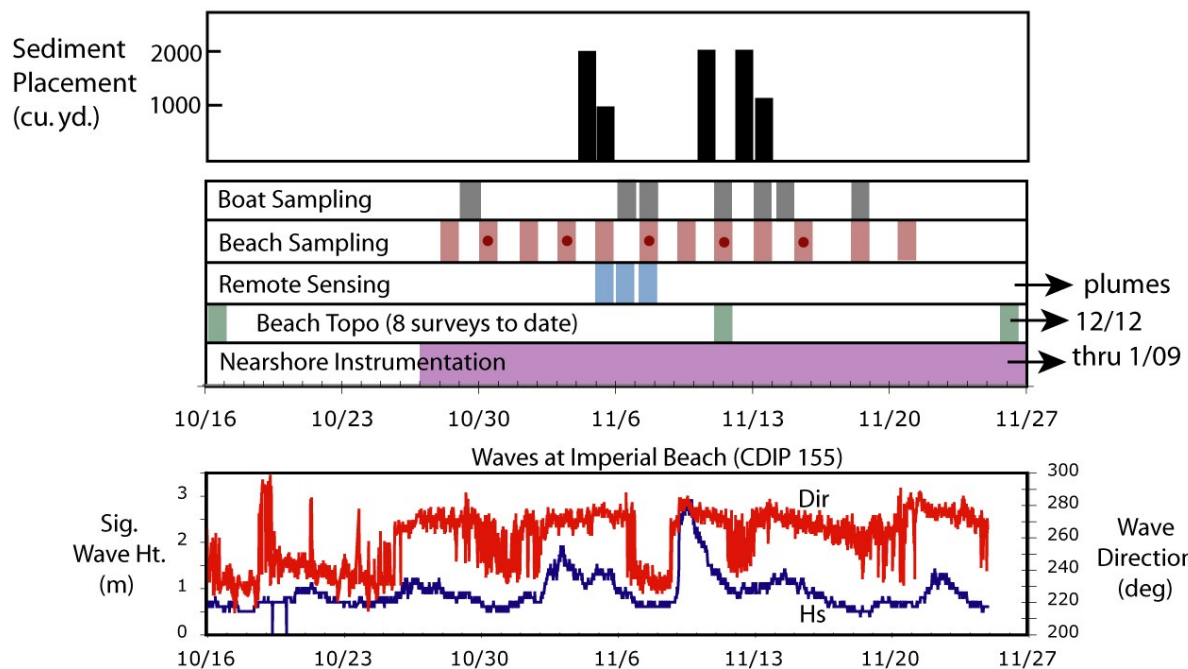
10,000 c.y.!!!
~~10,000 c.y.~~
~~40,000 c.y.~~



Sampling Locations for Placement No. 1



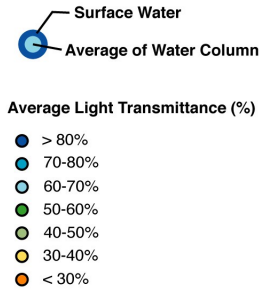
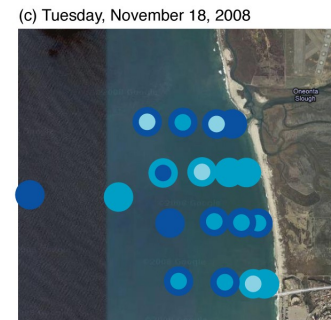
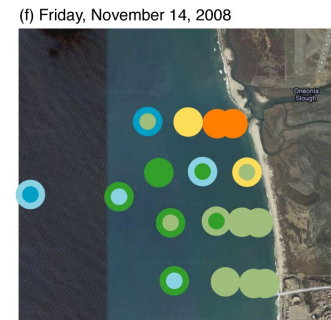
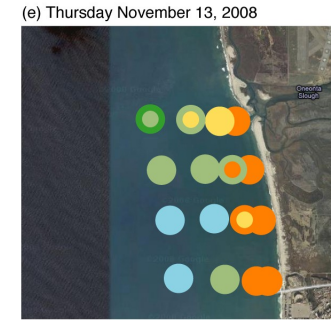
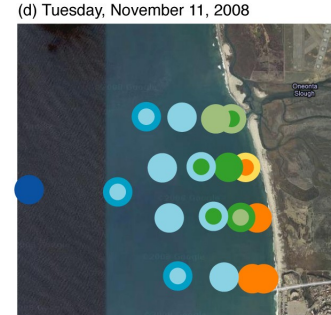
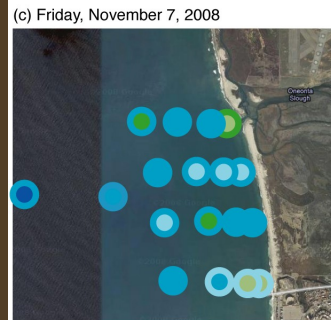
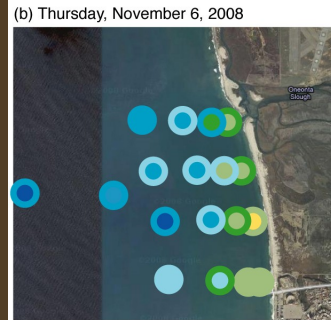
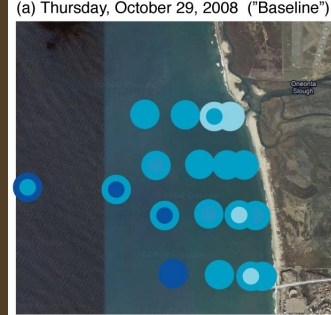
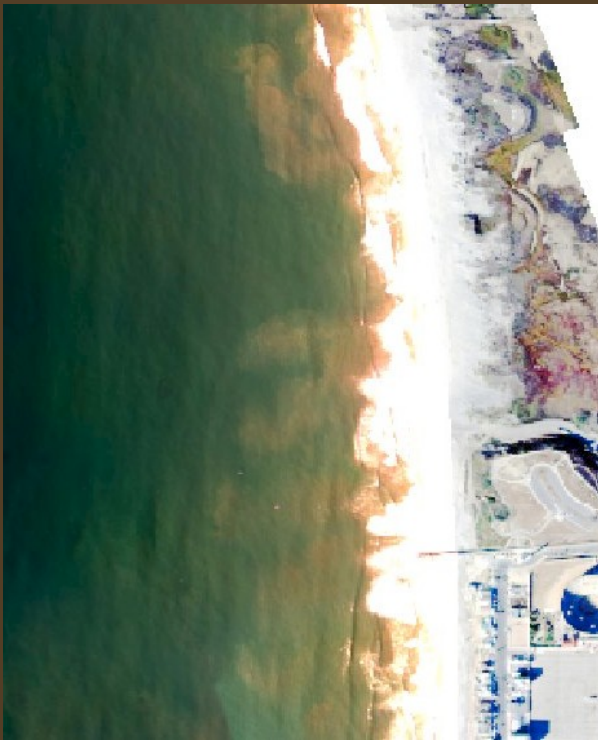
Tijuana Fate and Transport Project Timeline of Placement No. 1



Boat samples by USGS showing elevated turbidity during placement.

Nearshore Turbidity

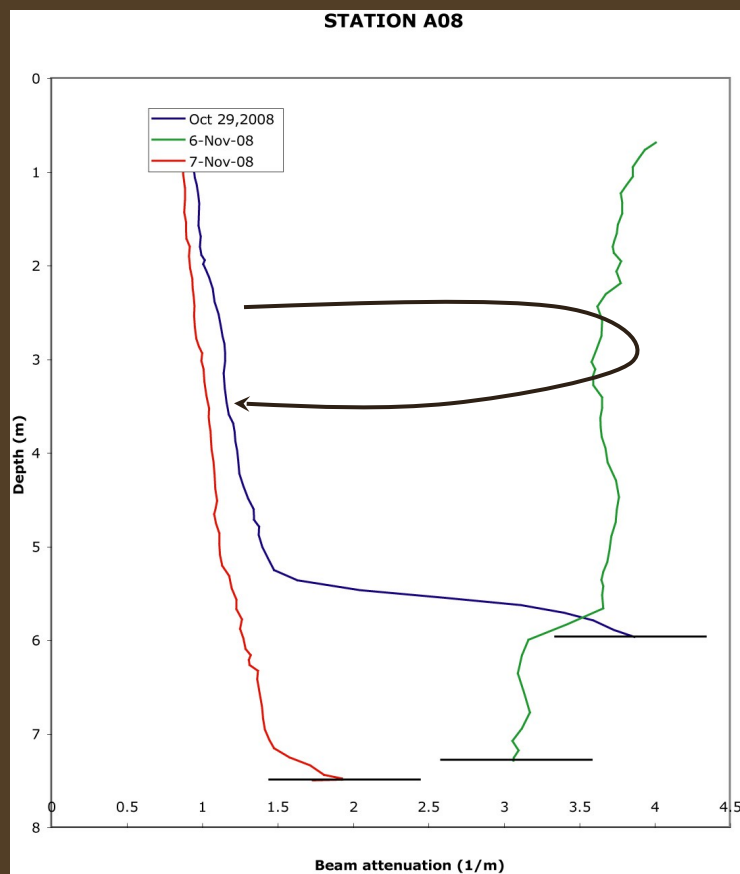
Remote Sensing by Ocean Imaging showing turbid rip cells.



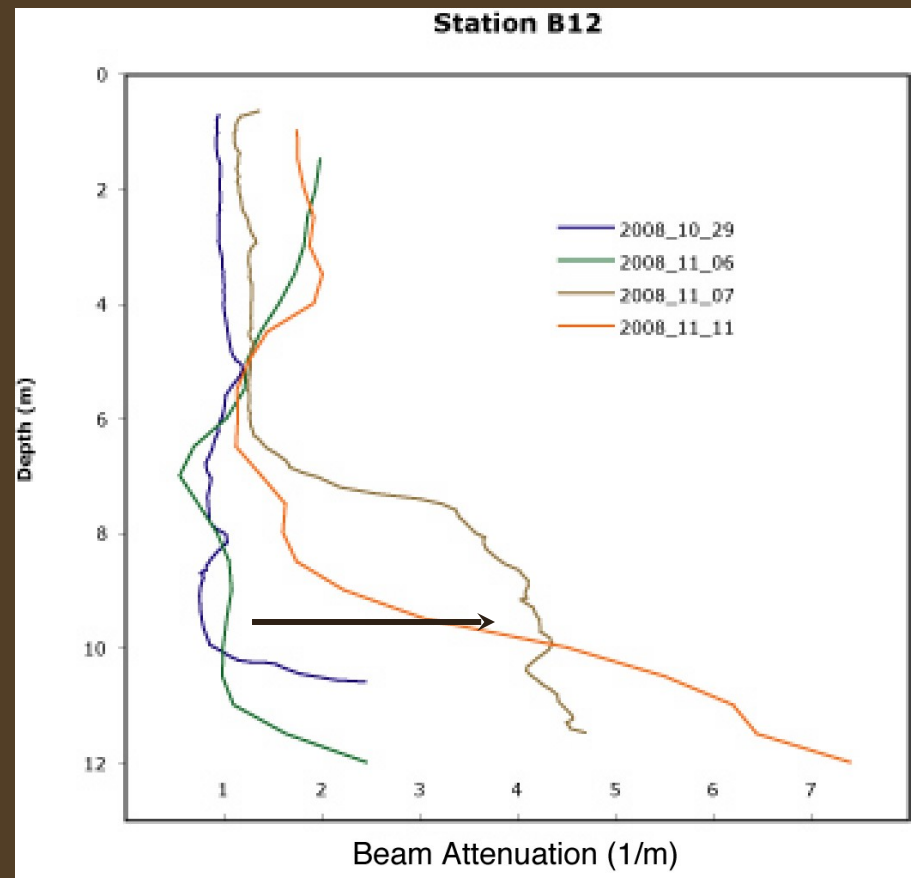
Nearshore Turbidity

Example boat samples from USGS showing an increase and decrease in turbidity during and after placement.

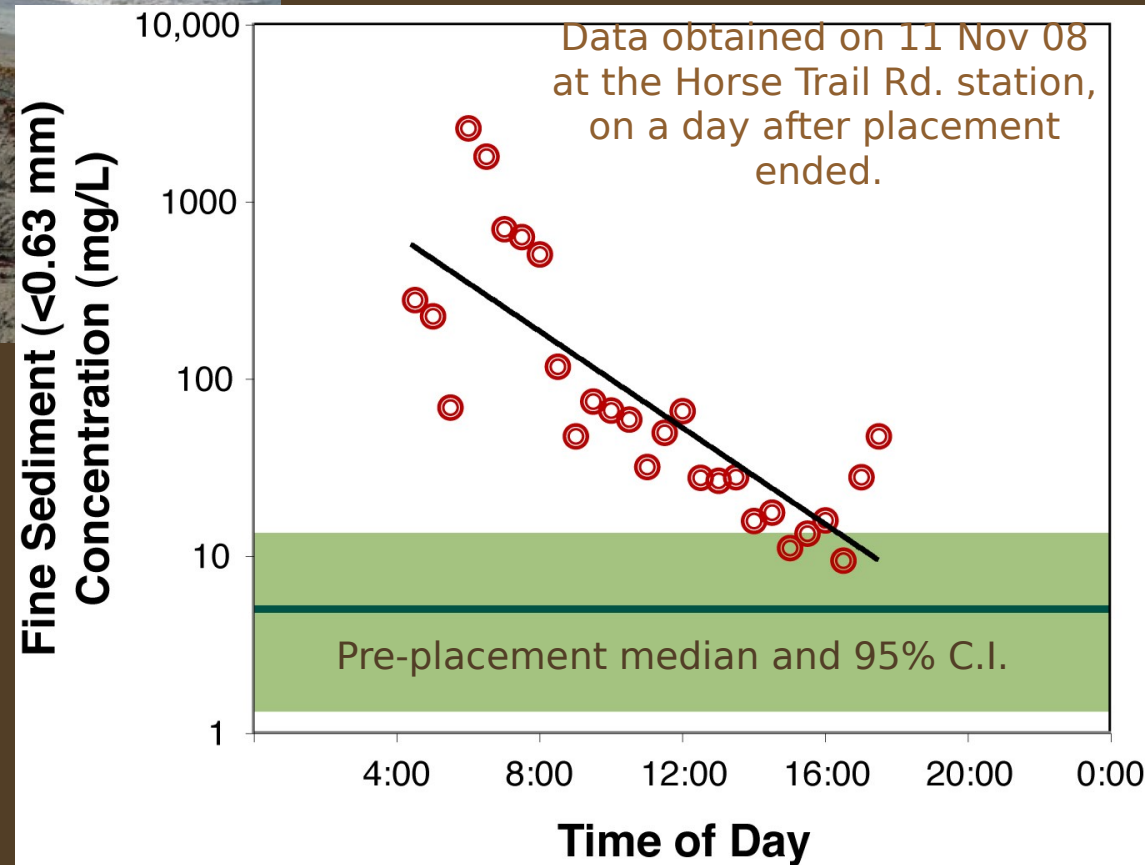
Within Rip Current Head



Outside Rip Current Heads



Surfzone Turbidity - Post Placement



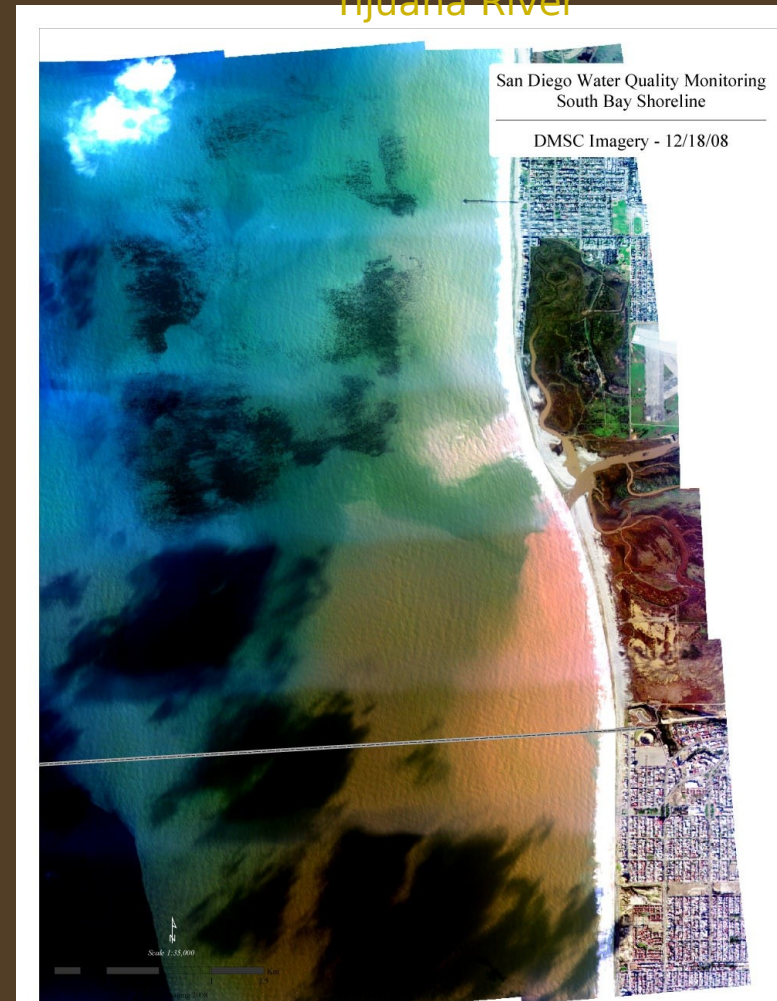
Comparison to River Discharge Event

Imagery from Ocean Imaging

Exceptional coastal turbidity following the 15 Dec 08 discharge event from the Tijuana River



Massive coastal turbidity following the 17 Dec 08 discharge event from the Tijuana River



Project Example 3 -

Santa Barbara Littoral Cell

PI: Patrick Barnard, Ph.D.

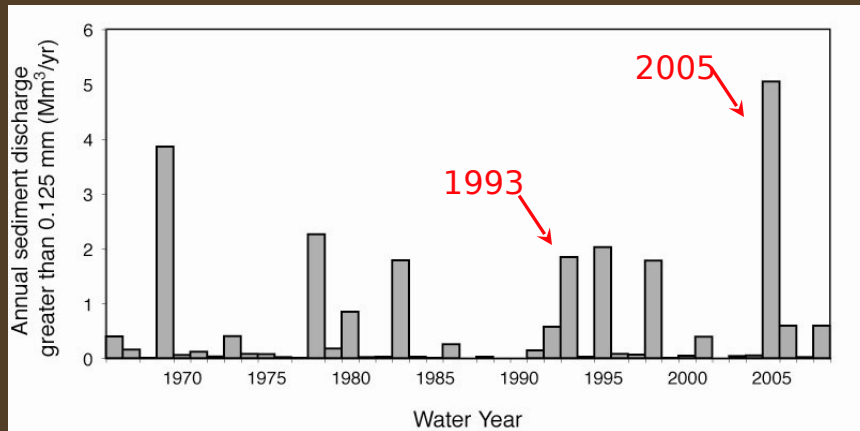
Project Goals:

- Quantify historical changes in beach width and shoreline position (Revell)
- Assess alongshore grain size variation onshore and nearshore and identify potential sand bodies (Mustain)
- Analyze nearshore processes and seasonal change
- Determine dominant sediment transport pathways and a sediment budget for the Santa Barbara littoral cell



Input of Sediment from River Discharge

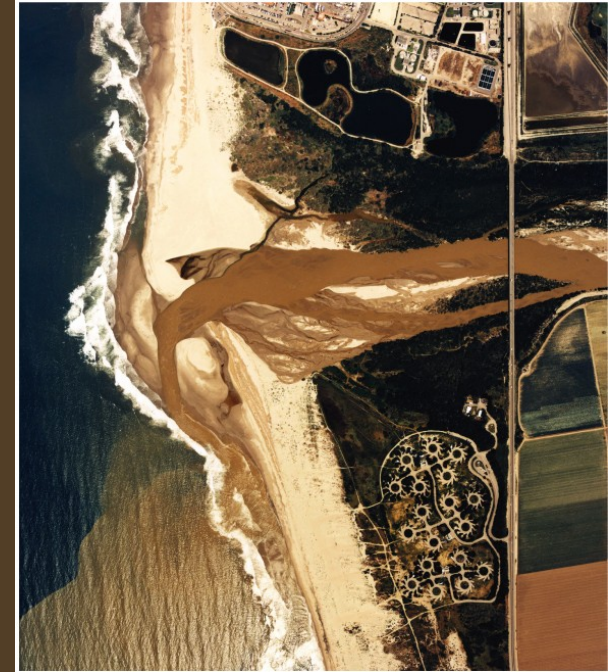
-Santa Clara River



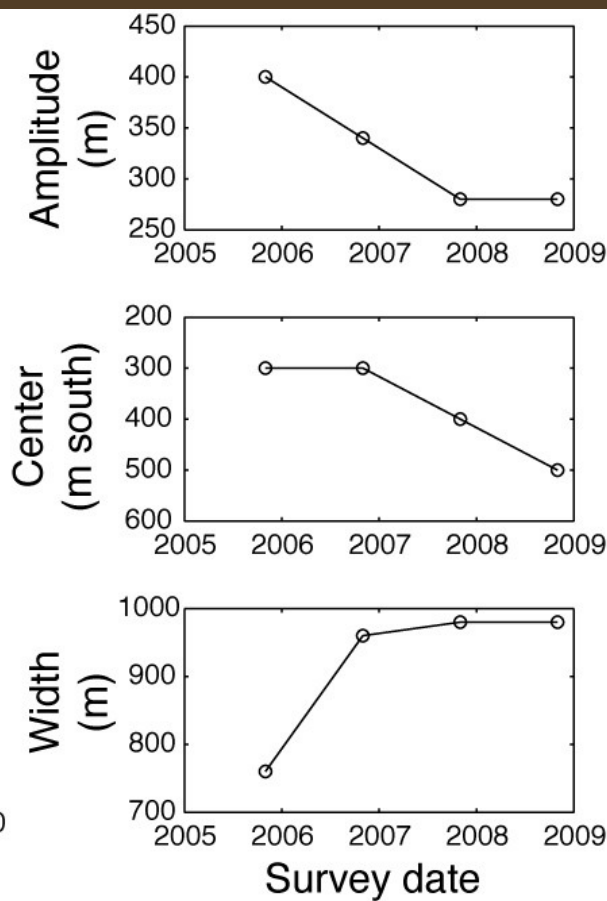
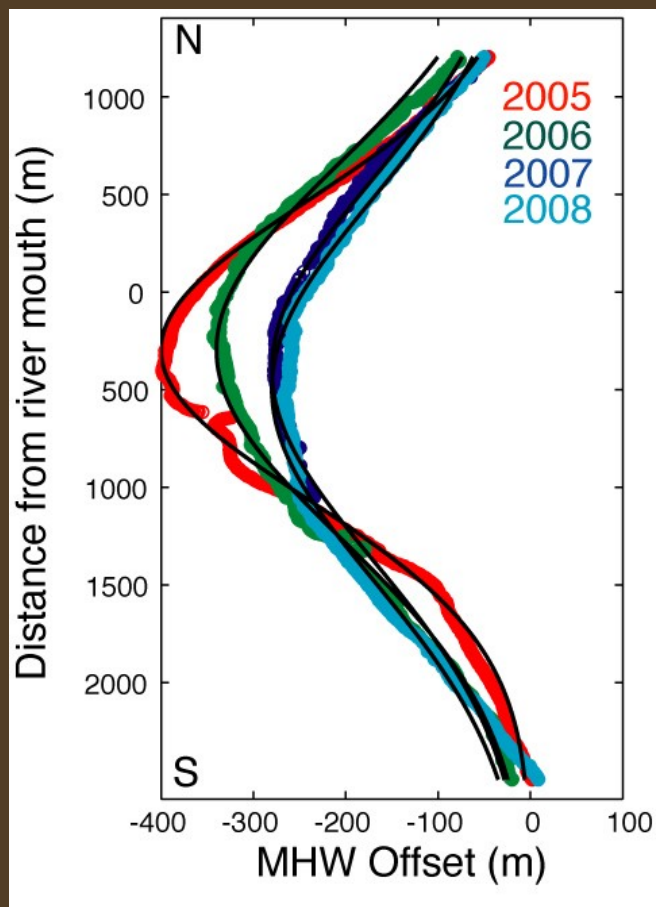
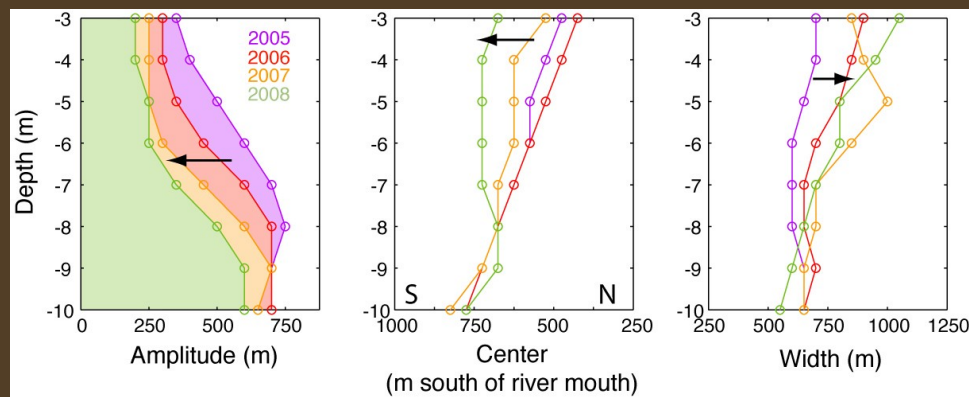
(a) March 17, 1987



(b) April 14, 1993



Evolution of the 2005 Santa Clara River Bar



diffusion

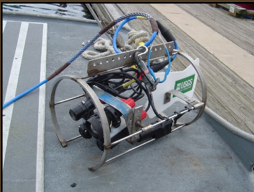
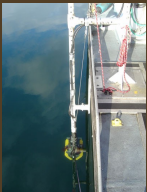
advection

diffusion

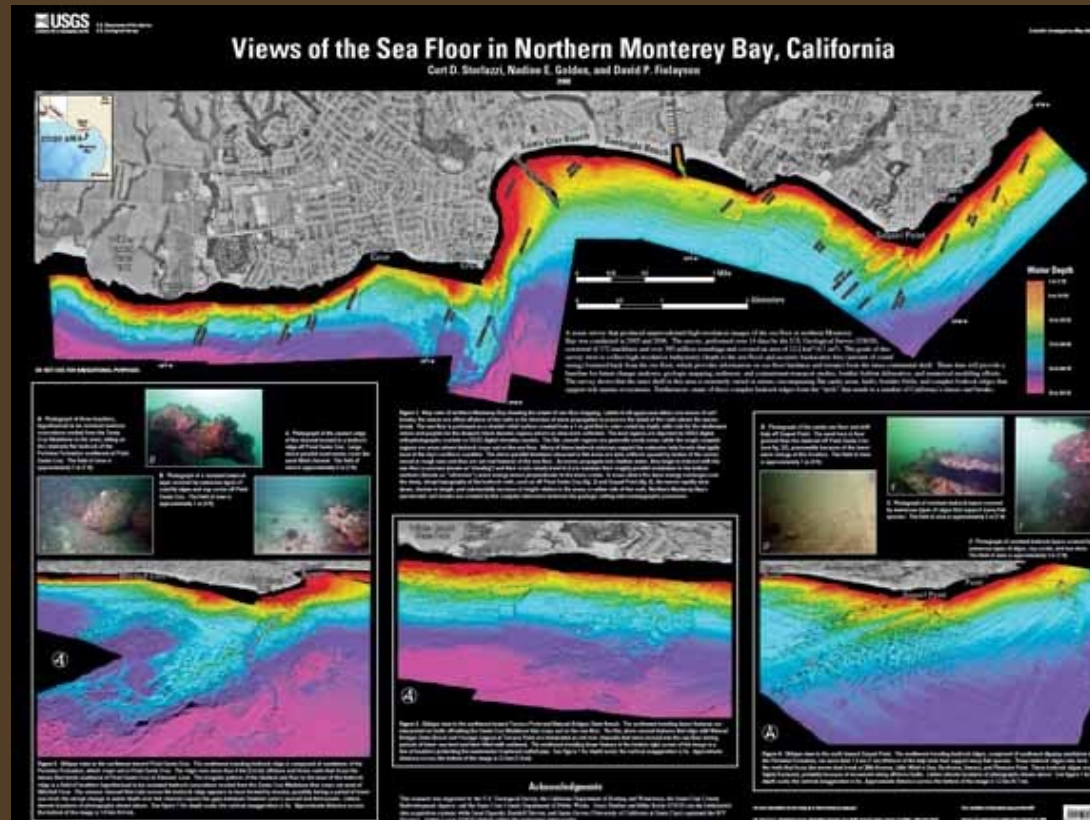
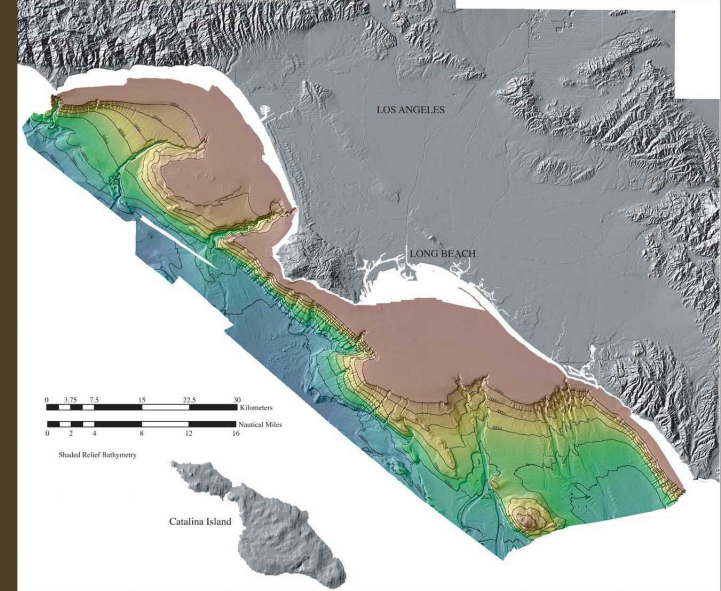
Project Example 4 -

California Seafloor Mapping

PI: Sam Johnson, Ph.D. and Guy Cochrane, Ph.D.

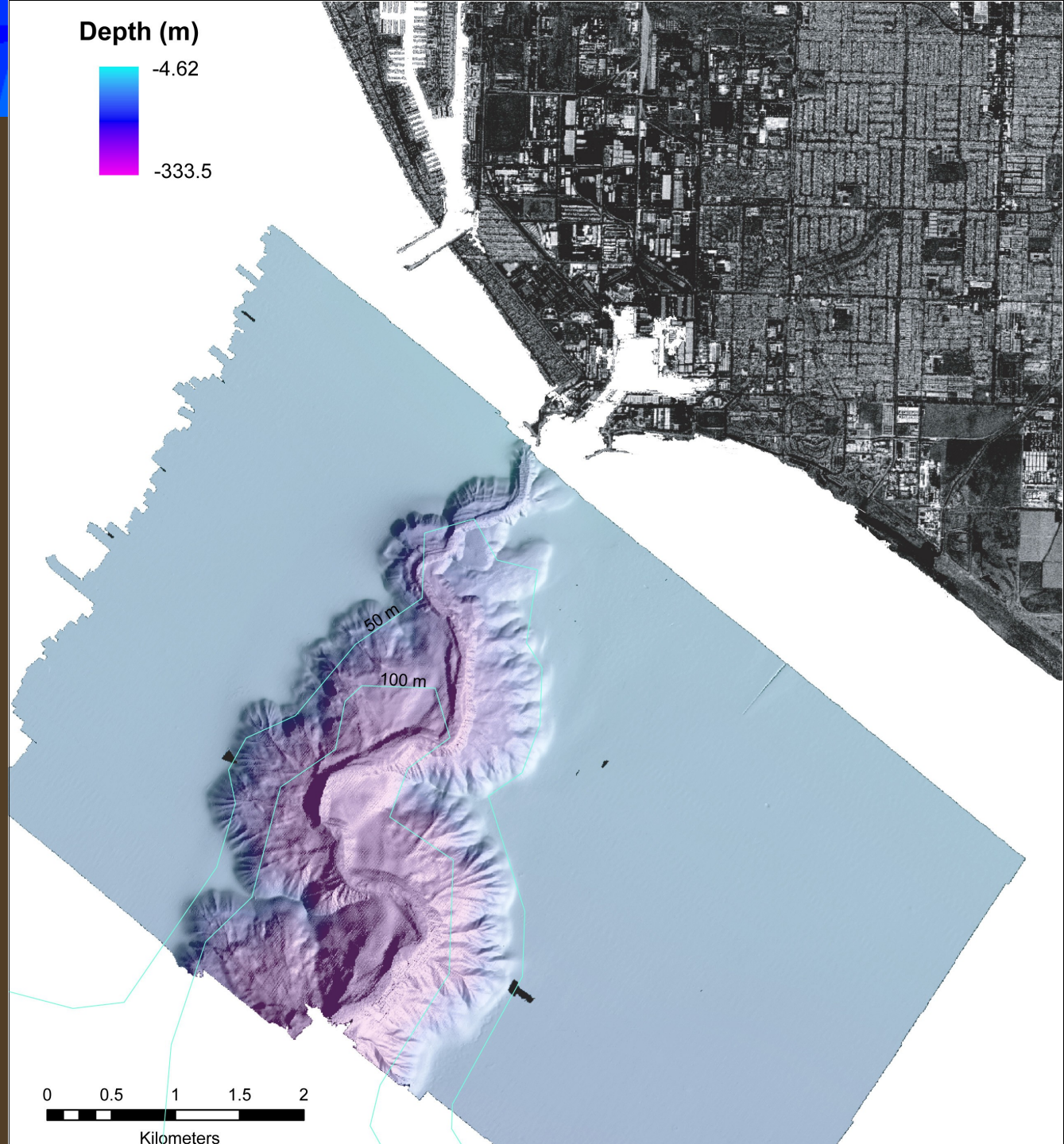


Sonar, video,
sampling...



CA Seafloor Mapping

Hueneme Canyon



Publication

S

Journal of Coastal Research SI 35 PR 24 KS2009 (Proceedings) Portugal ISSN

Monitoring and modeling shoreline response due to shoreface nourishment on a high-energy coast

P.L. Barnard¹, L.H. Erikson and J.E. Hansen
¹Department of Earth Sciences,
University of California, Santa
Barbara, CA, USA
pbarnard@ucsb.edu



ABSTRACT

BARNARD, P.L., ERIKSON, L.H., and HANSEN, J.E., 2009. Monitoring and modeling shoreline response due to shoreface nourishment on a high-energy coast. *Journal of Coastal Research*, SI 35 (Proceedings of the 10th International Coastal Symposium), pp. 24. Lisbon, Portugal, 2009.

Shoreface nourishment can be an efficient technique to feed sediment into the littoral zone without the wider of

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Sedimentary Geology 210 (2007) 180–190

Sedimentary Geology

www.elsevier.com/locate/sedgeo

Field test comparison of an autocorrelation technique for determining grain size using a digital 'beachball' camera versus traditional methods

Patrick L. Barnard^{a,*}, David M. Rubin^b, Jodi Harney^a, Neomi Mustain^b

^a United States Geological Survey, Coastal and Marine Geology Team, Pacific Science Center,
800 Natural Bridges Drive, Santa Cruz, CA 95060, United States
^b Department of Earth and Planetary Sciences, University of California, Santa Cruz, 1151 High Street, Santa Cruz, CA 95060, United States
Received 27 June 2006; received in revised form 18 May 2007; accepted 22 May 2007

Abstract

This extensive field test of an autocorrelation technique for determining grain size from digital images was conducted using a digital bed-sediment camera, or 'beachball' camera. Using 205 sediment samples and >1200 images from a variety of beaches on the west coast of the US, grain size ranging from sand to gravel was measured from field samples using both the autocorrelation technique developed by Rubin (Rubin, D.M., 2004. A simple autocorrelation algorithm for determining grain size from digital images of sediment. *Journal of Sedimentary Research*, 74(1), 160–165) and traditional methods (i.e. settling tube analysis, sieving, and point counts). To test the accuracy of the digital-image grain size algorithm, we compared results with manual point counts of an extensive image data set in the Santa Barbara littoral cell. Grain sizes calculated using the autocorrelation algorithm were highly correlated with the point counts of the same images ($r^2=0.93$, $n=79$) and had an error of only 3%. Comparisons of calculated grain sizes and grain sizes measured from grab samples demonstrated that the autocorrelation technique works well on high-energy dissipative beaches with well-sorted sediment such as in the Pacific Northwest ($r^2=0.92$, $n=115$). On less dissipative, more poorly sorted beaches such as Ocean Beach in San Francisco, results were not as good ($r^2=0.76$, $n=87$, within 3% accuracy). Because the algorithm works well compared with point counts of the same image, the poorer correlation with grab samples must be a result of actual spatial and vertical variability of sediment in the field, closer agreement between grain size in the images and grain size of grab samples can be achieved by increasing the sampling volume of the images (taking more images, distributed over a volume comparable to that of a grab sample). In 2D field tests the autocorrelation method was able to predict the mean and median grain size with ~90% accuracy, which is more than adequate for the majority of sedimentological applications, especially considering that the autocorrelation technique is estimated to be at least 100 times faster than traditional methods.

Keywords: Grain size; Digital image; Beach; Bed sediment

1. Introduction

Grain size analysis has traditionally been a long and arduous task, utilizing either mechanical sieving (Krumbein and Pettigrew, 1938), settling tube (Gibbs,

Sediment yield from the tectonically active semiarid Western Transverse Ranges of California

Jonathan A. Warrick^a and Leal A.K. Mertes^b

^aUSGS Western Coastal and Marine Geology, 400 Natural Bridges Drive, Santa Cruz, California 95060, USA
^bDepartment of Geography and Institute for Computational Earth System Science, University of California, Santa Barbara, California 93106, USA

ABSTRACT

Sediment yields from the world's rivers are generally highest from steep drainage basins with weak lithology, active tectonics, or severe land-use impacts. Here, we evaluate sediment yields from the Western Transverse Ranges of California in an attempt to explain why they are two to tenfold greater than the surrounding areas of California. We found that suspended-sediment yields across the gauged basins of the Western Transverse

Range during 1960s mostly in order of km²/yr. Similarly, flows for normality by almost two orders of magnitude for the mean

Yucca Mountains, a yields consistently a bedrock (Quaternary formations) and are a rates of tectonic up



Suspended-sediment rating curve response to urbanization and wildfire, Santa Ana River, California

Jonathan A. Warrick^a and David M. Rubin^b

^aUSGS Western Coastal and Marine Geology, 400 Natural Bridges Drive, Santa Cruz, CA 95060, United States
^bDepartment of Earth and Planetary Sciences, University of California, Santa Cruz, 1151 High Street, Santa Cruz, CA 95060, United States
Received 27 June 2006; received in revised form 18 May 2007; accepted 22 May 2007

River suspended-sediment concentrations provide insights to the erosion and transport of materials from a landscape, and changes in concentrations with time may result from landscape processes or human disturbance. Here we show that suspended-sediment concentrations in the Santa Ana River, California, decreased 20-fold with respect to discharge during a 34-year period (1968–2001). These decreases cannot be attributed to changes in sampling technique or timing, nor to event or seasonal hysteresis. Annual peak and total discharge, however, reveal sixfold increases over the 34-year record, which largely explain the decreases in sediment concentration by a nonlinear dilution process. The hydrological changes were related to the widespread urbanization of the watershed, which resulted in increases in storm water discharge without detectable alteration of sediment discharge, thus reducing suspended-sediment concentrations. Periodic upland wildfire significantly increased water discharge, sediment discharge, and suspended-sediment concentrations and thus further altered the rating curve with time. Our results suggest that previous inventories of Southern California sediment flux, which assume time-constant rating curves and extend these curves beyond the sampling history, may have substantially overestimated loads during the most recent decades.

Keywords: Warrick, J. A., and D. M. Rubin (2007). Suspended-sediment rating curve response to urbanization and wildfire, Santa Ana River, California. *J. Geophys. Res.*, 112, F02018, doi:10.1029/2006JF004662.

1. Introduction

[1] Sediment flux measurements from rivers are important for evaluating terrestrial organic and inorganic material export, landscape denudation, geomorphic change, habitat and water quality, and inputs to reservoir and coastal systems. Rates of sediment discharge are related to the erosion, transport and storage of sediment within a watershed, which are in turn related to tectonic regimes, climate, land use, and river setting (McManus and Syvitski, 1992; Dineen et al., 1998; Trimble, 1997, 1999; Barnard and Anderson, 2001; Jorg et al., 2005). Global inventories of river discharge suggest that both accelerated rates of soil erosion and trapping of sediment by dams have almost three fluxes during recent decades (Wallace and Fung, 2002; Syvitski et al., 2005).

[2] The first fluvial, and commonly the majority, of river sediment flux is transported below theoretical transport capacities, which necessitates the development of site-specific, empirical relationships to compute flux (Collyer, 1963; Powers et al., 1972; Walling, 1977). These empirical relationships between river discharge and suspended-sediment concentration respond to patterns of sediment production availability and transport capacity throughout a watershed, which may include sediment production variability of river channels (Meade et al., 1996; Hicks et al., 2000; Lane and

Meade, 2000), changes in bed sediment grain size (Rubin and Topping, 2001), flow rate dynamics and event hysteresis (Walling, 1974; Williams, 1989; Rubin and Topping, 2001), and seasonal to interannual changes in sediment supply (Lepold, 1948; Walling, 1974; Van Sickle and Brooks, 1983; Dineen, 1998; Anderson, 2000; Topping et al., 2000). Thus simple sediment rating curve relationships (i.e., power law) may not adequately reproduce the variability in sediment production, and hence flux, owing to nonlinear or time-dependent effects (e.g., Van Sickle and Brooks, 1983; Hicks et al., 2000; Hovius et al., 2000; Norowitz, 2003). Further, a comprehensive analysis of North American suspended-sediment rating curves suggests that water discharge also plays a controlling factor in the curve variability (Syvitski et al., 2000), although little work has examined the effects of hydrologic change on rating curves.

[3] The rivers of southern California drain a semiarid landscape that has been subject to periodic wildfires, extensive population and urban growth, and channel modifications including large dams (Barnard and Taylor, 1981; Jorg and Anderson, 1999; Lane and Barnard, 2004). These rivers are also recognized to be highly event-driven, modulating the majority of long-term discharge and sediment flux during brief, intense winter events (Kjell, 1975; Hovius and Melnick, 2003). Thus, owing to their small size, high relief, active tectonics, and history of human demographic modification, southern California rivers serve as examples of high-sediment-yield, small, mountainous rivers with considerable human modification (McManus and Syvitski,

F02018

1 of 15

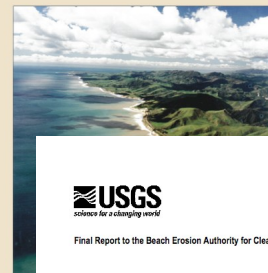
Earth Science in the Urban Ocean: The Southern California Continental Borderland

Edited by Peter J. Lee and William R. Boettcher



USGS
science for a changing world

Sources, Dispersal, and Fate of Fine Sediment Supplied to Coastal California



Scientific Investigator

U.S. Department of the U.S. Geological Survey

USGS
science for a changing world

Final Report to the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON)

Coastal Processes Study of Santa Barbara and Ventura

Counties, California

By Patrick L. Barnard, David L. Revell, Dan Hoover, Jon Warrick, John Brociani, Amy E. Drost, Pete Dornell, Edwin Elias, Neomi



Open File Report 2009-1029

U.S. Department of the Interior U.S. Geological Survey

Open File Report 2009-1029



Open File Report 2009-1029

U.S. Department of the Interior U.S. Geological Survey

Also:
Shi et al. (in review) JGR-Oceans
Barnard and Warrick (in review) JGR-Earth Surface
Ph.D. Dissertation (Peel), MS Thesis (Mustain)

Thank You.

jwarrick@usgs.gov



Pacific
Ocean

County

San
Francisco
Bay

San
Francisco

Pt. Lobos

Ocean Beach

Erosion

Ship Channel

SF-8

Depth change

1956 to 2005 (NAVD 88)

- > 2 m erosion
- 1 to 2 m erosion
- 0.5 to 1 m erosion
- +/- 0.5 m
- 0.5 to 1 m accretion
- 1 to 2 m accretion
- > 2 m accretion

- SF-8 Disposal Site
- SF-8 Mounds



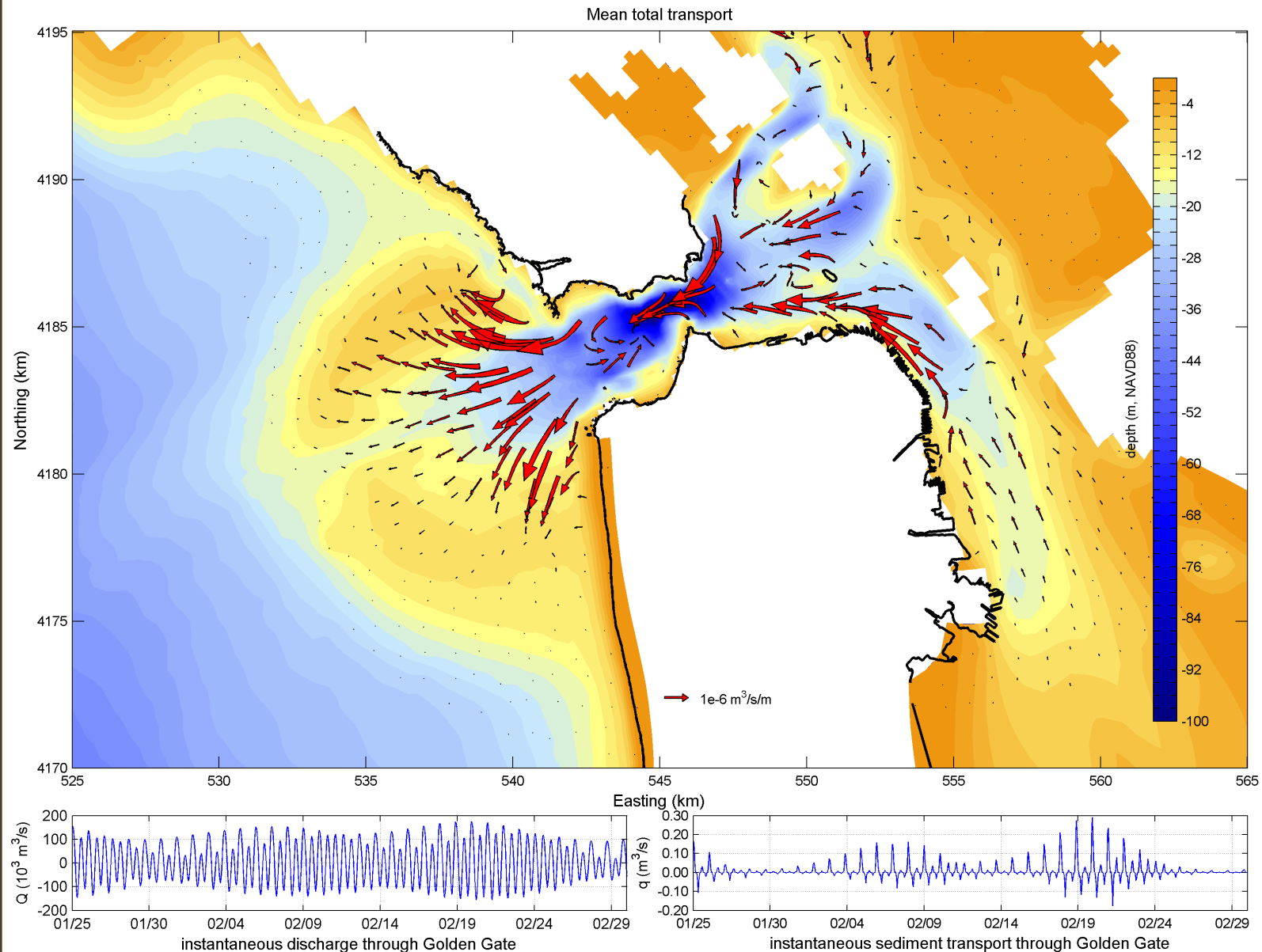
Kilometers

Ebb Tidal Delta Change (1956-2005)

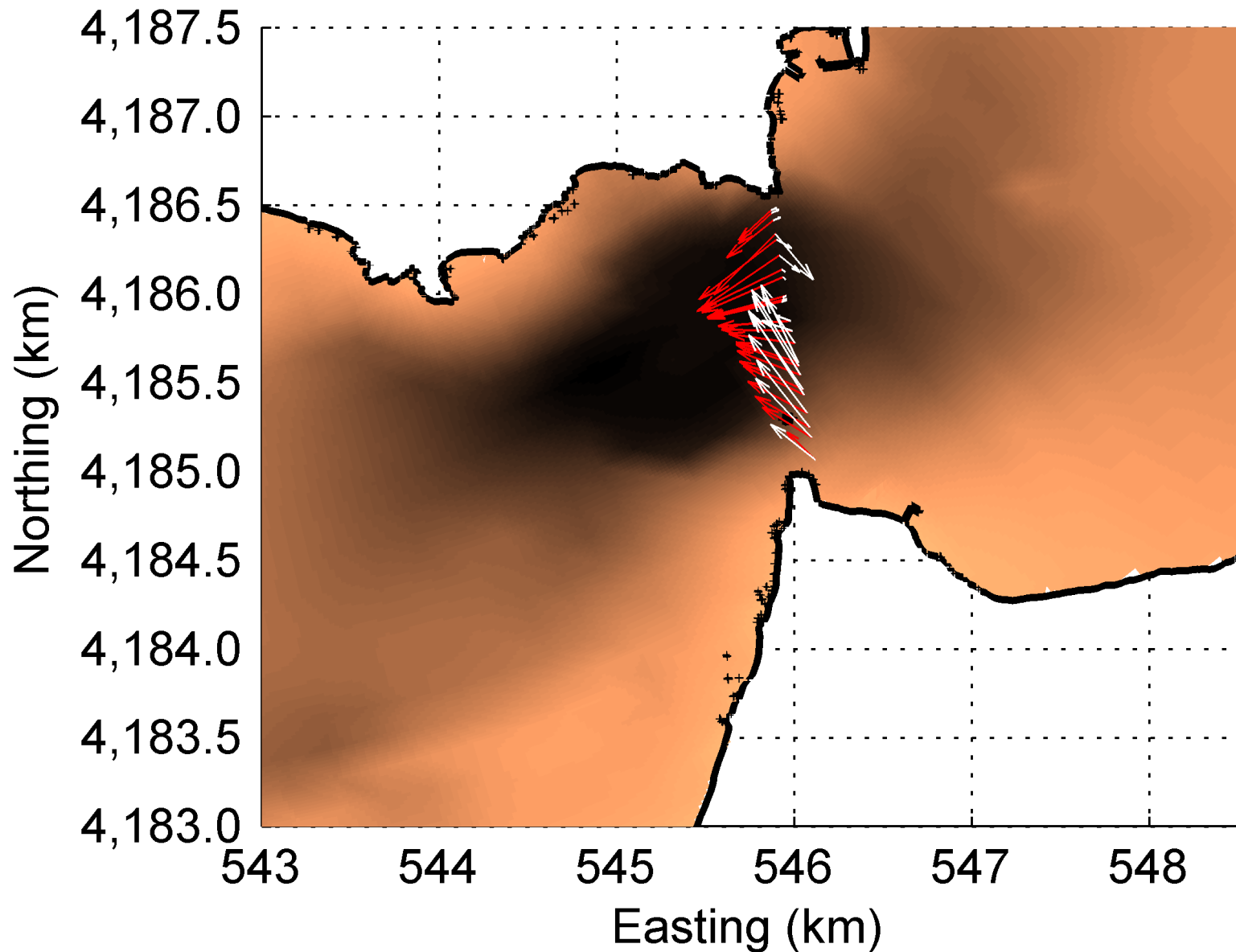
mean vertical change = -60 cm (erosion)

total volume change = -92,000,000 m³

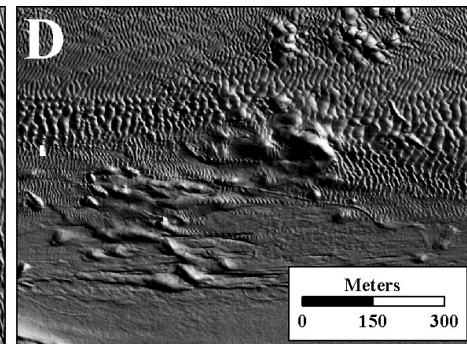
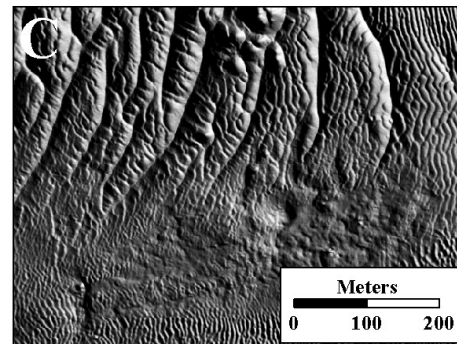
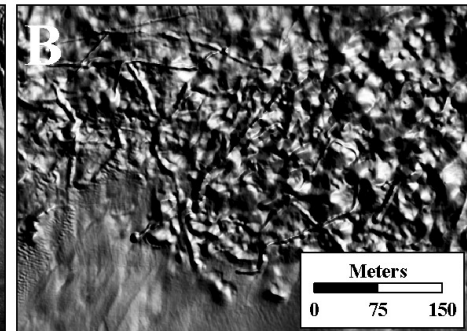
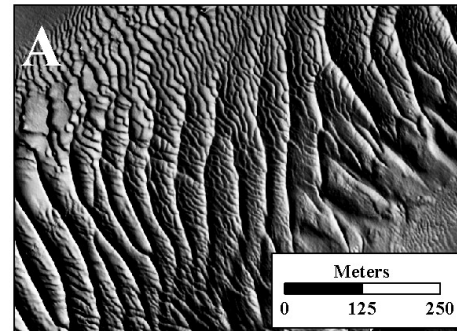
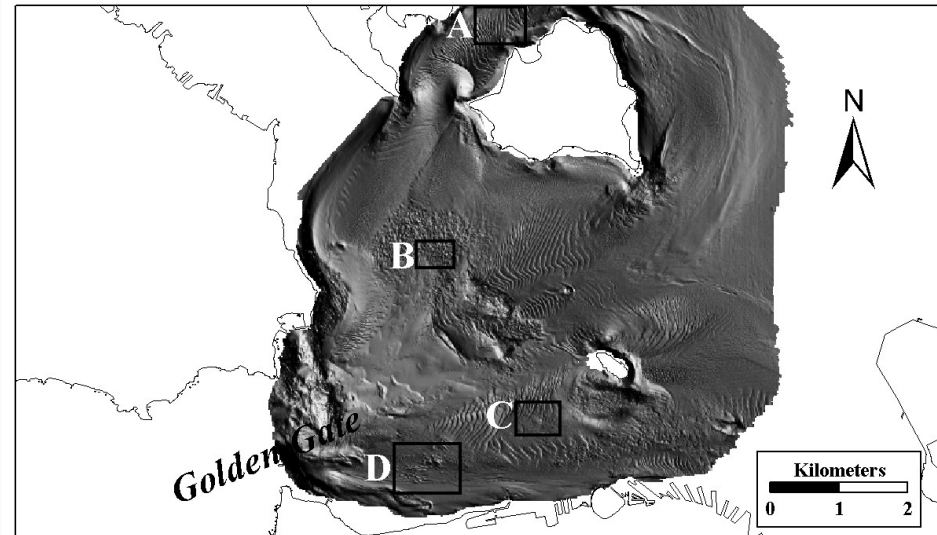
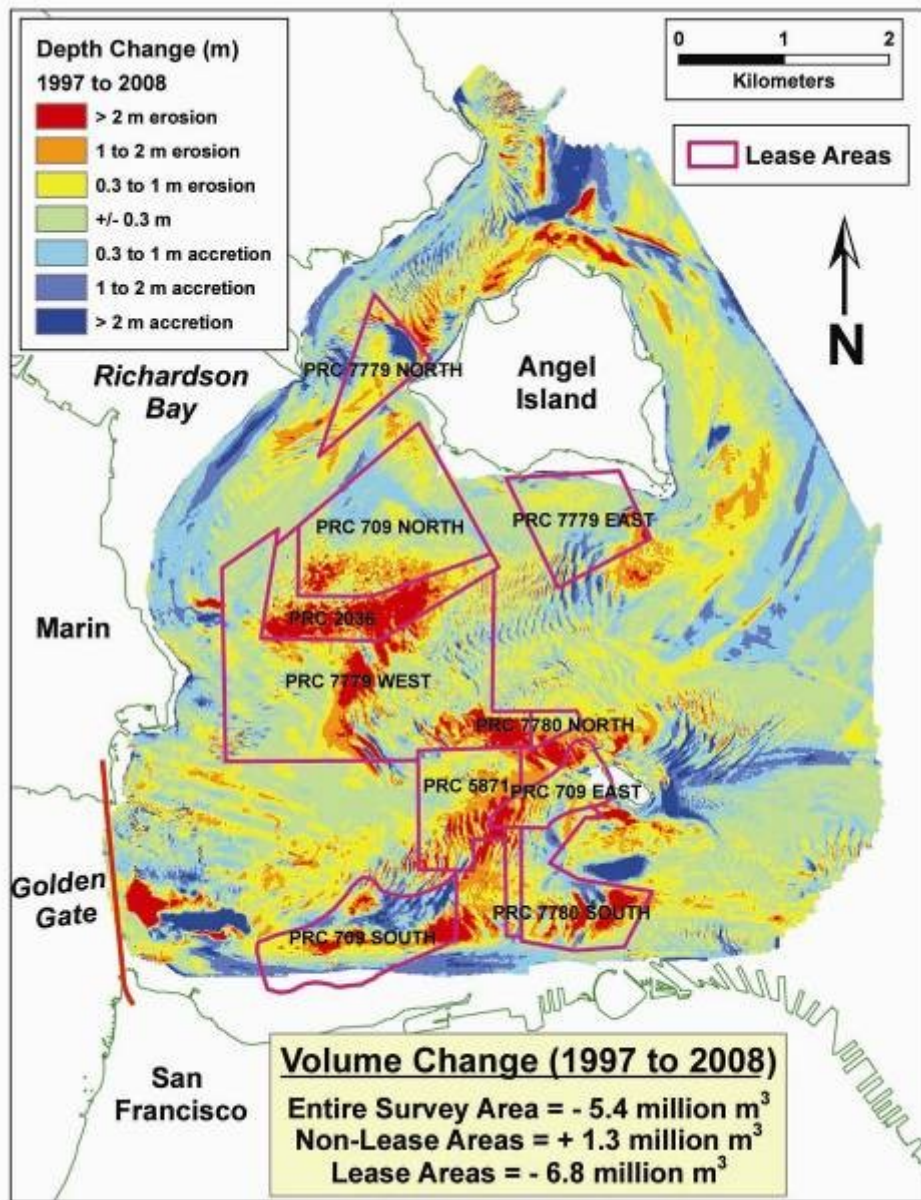
Predicted sediment transport - 'hydrodynamic ti



Net Sediment Flux

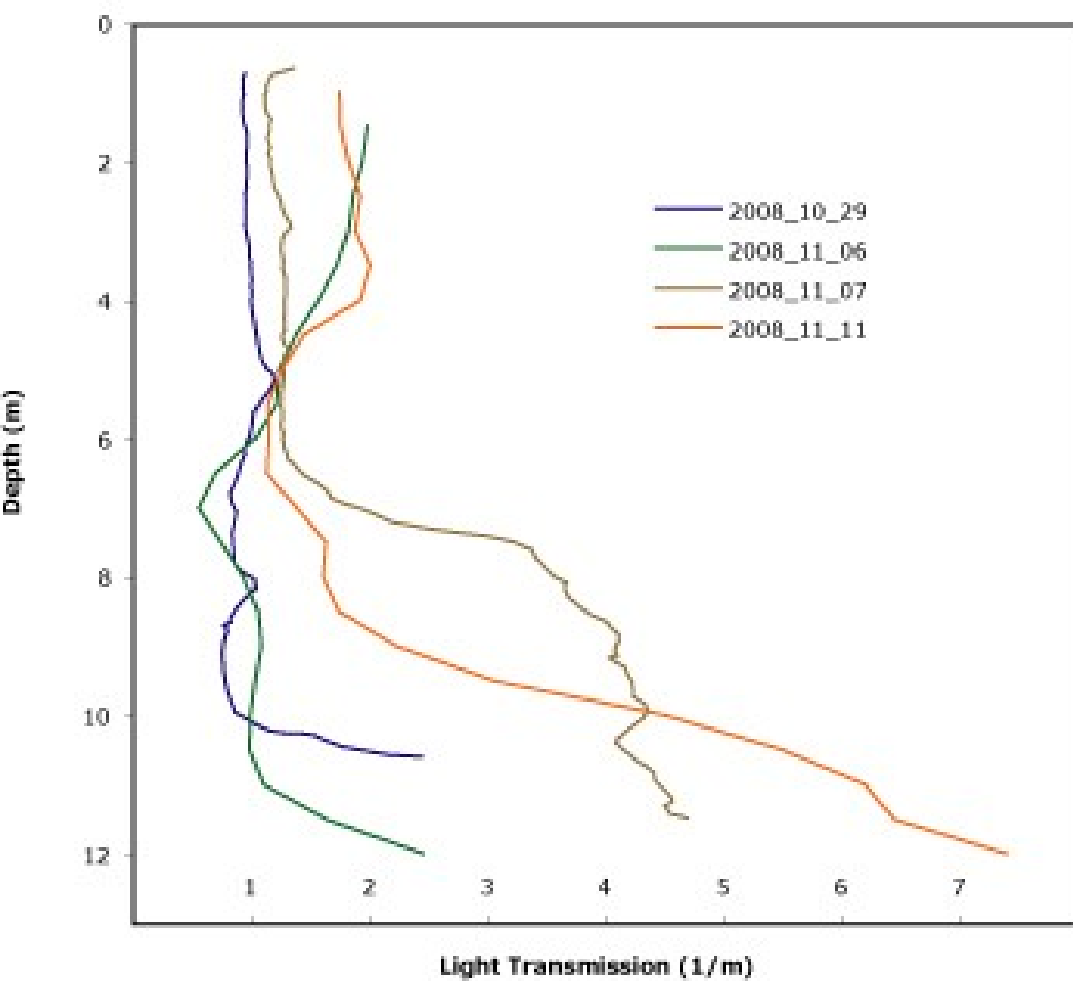


2008 Multibeam Survey

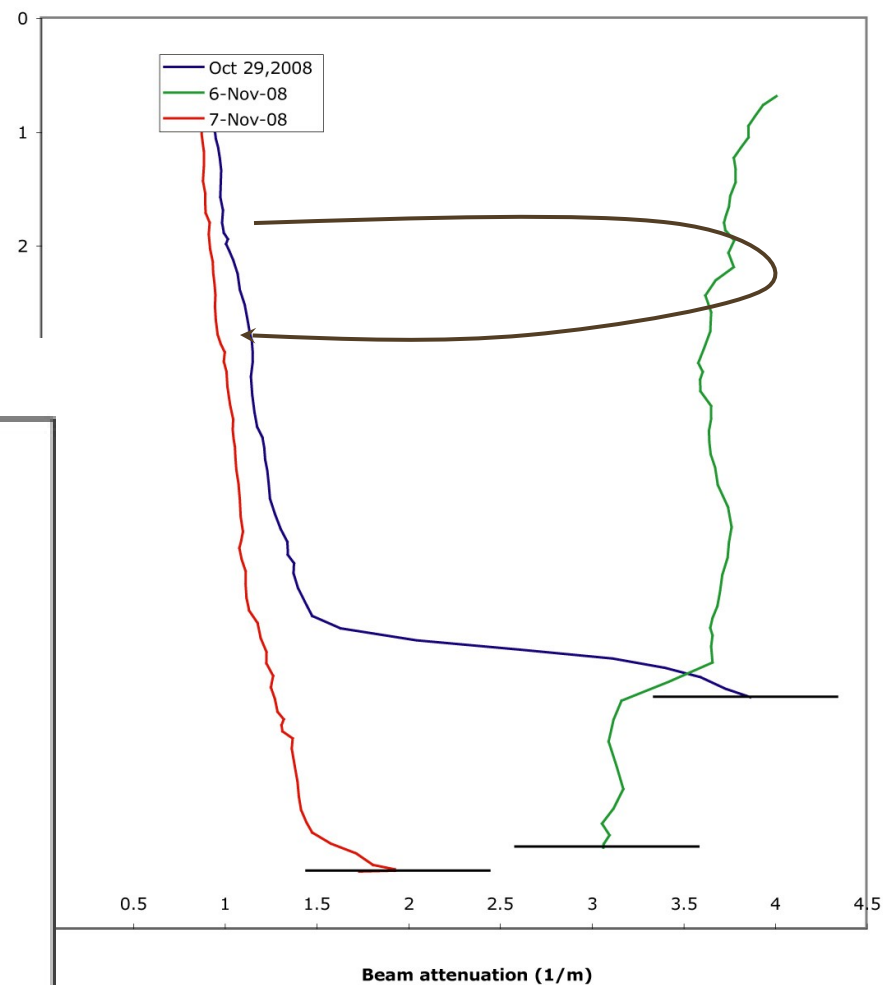


Nearshore Turbidity

Station B12

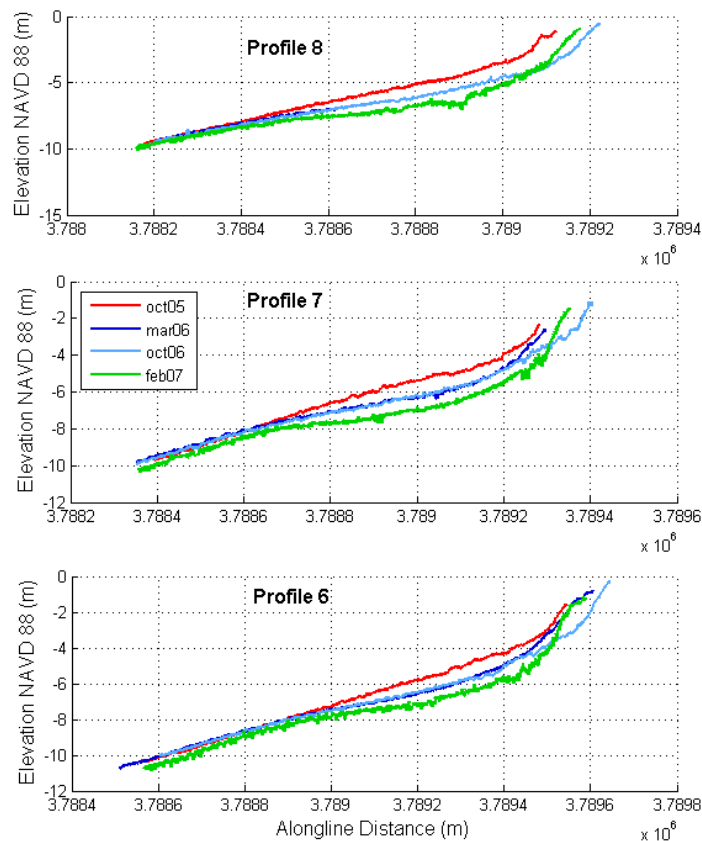
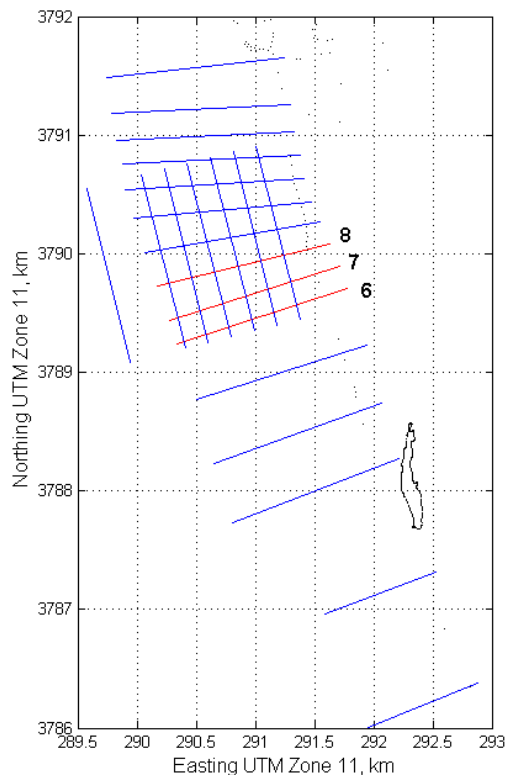
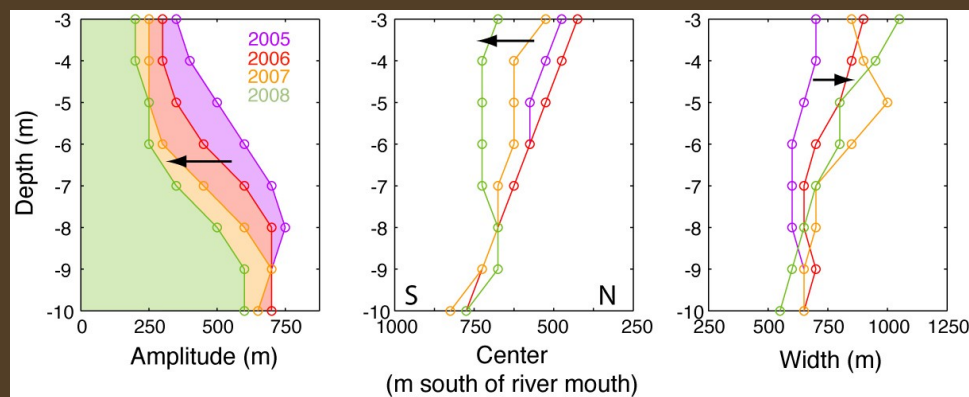


STATION A08

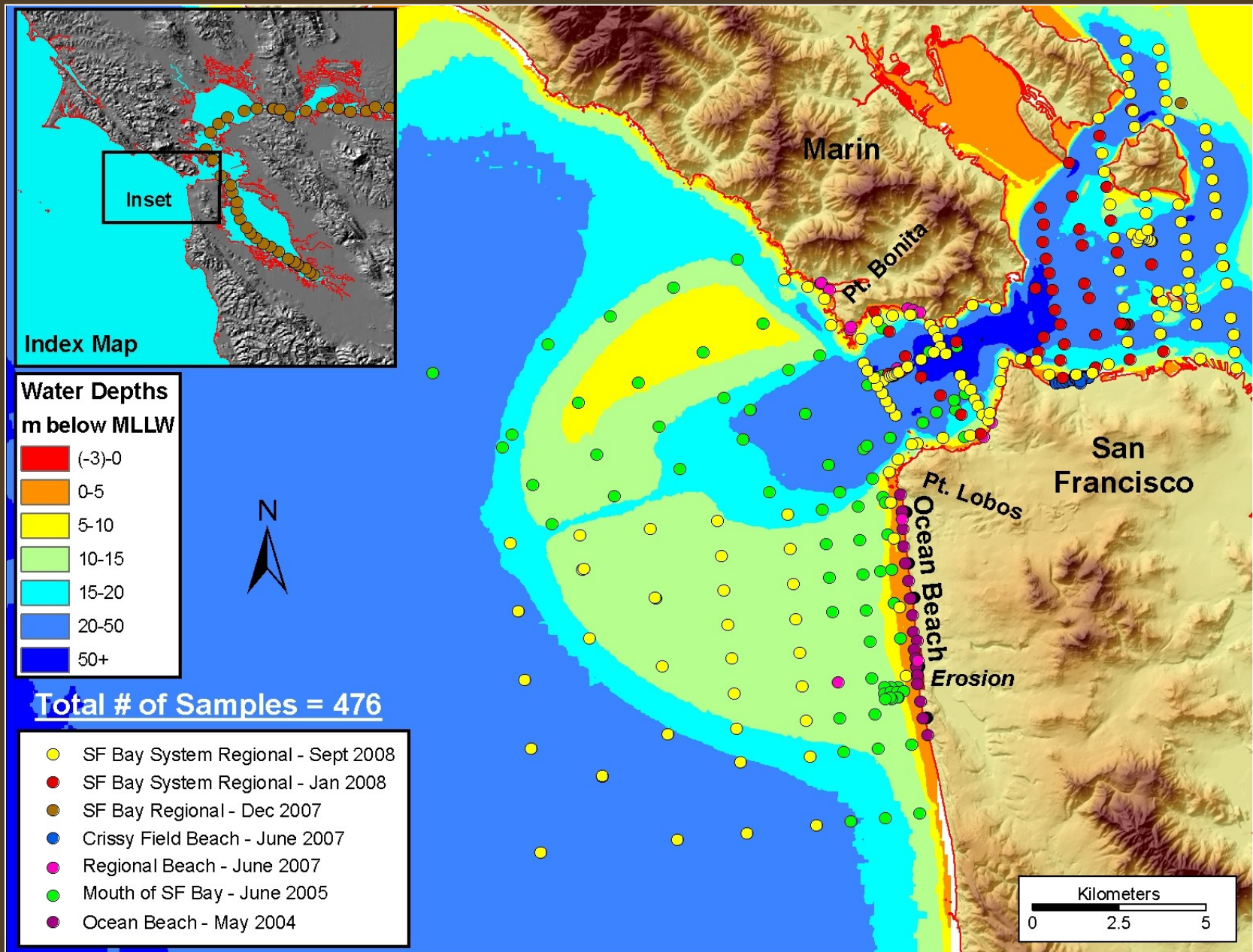


turbidity profiles for the inshore southern station (A08) for the Tijuana
on Project. The horizontal line for each cast represents the seabed,
for each day owing to tidal stage. Turbidity as measured by light
is approximately three-fold greater on Nov. 6, 2008 - a day for which a
lume was observed from the Project site - than on the other dates.
PROVISIONAL AND HAVE NOT BEEN VERIFIED AND APPROVED BY USGS
VIEW.

Evolution of the 2005 Santa Clara River Bar



Recent Sediment Sampling



Grain Size

